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A NEW SYSTEM OF CONNECTIONS FOR LARGE ELECTRIC POWER STATIONS

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/Figures referred to in text are appended./

Introduction

The possibility of building 3-phase transformers up to 60,000 kva in single units with a high voltage of 220 kv and the operational experience already accumulated shows the exceptional reliability of these installations and makes possible a new system of connections for large electric power stations which will reduce the cost of basic equipment and lead to increased reliability and convenience of operation.

The data below refers to a new system of connections using these large, 3-phase transformers for one concrete example, viz., an electric power station with six turbogenerators, each of 50,000 kw, delivering their full output to a 220-kv circuit along three power transmission lines. The principle can be applied to other cases where the ratings of the generators and transformers differ from the above. In order to save space, the problem of station power requirements is not dealt with.

Usual Connection Systems

For the electric power station referred to, one usually considers the following variants of the connection systems:

In the first variant, all the generators are united into blocks with 10/220 kv step-up tranformers consisting of groups of single-phase transformers, the total power of each group being 60,000 kva. Each such block is connected to two systems of collector busbars by means of one breaker and two disconnectors. Three 220-kv transmission lines, similarly connected to the collector busbars, run from the busbars. This system of connections has considerable drawbacks, viz.,

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1. In order that damage to the busbars shall not result in the loss of all the power of the station, normally both busbar systems are under voltage, each being connected to half of the generators and power transmission lines. Under these conditions, when the busbars are damaged, half the power of the station will be lost, and when the number of generators or transmission lines is uneven, i.e., when the power cannot be divided evenly between the two systems of busbars, damage to one of them may result in loss of more than half the power of the station.

2. Splitting lines and generators between two systems entails fixed connection between them. If it is necessary to change over a generator or line from one system to the other, it is necessary to reconstruct the differential protection of the busbars.

3. Inspecting each of the collector busbar systems and breakers involves a considerable number of switchings of the busbar disconnectors.

Figure 1 shows a variation of the connection system of the same station, with a larger (120,000 kva) transformer in the group. Each transformer group and electric transmission line is connected to the collector busbars by means of two breakers. Both busbar systems are normally in operation. Each generator can work independently, since each is fitted with a generator voltage breaker.

This second variation does not have the drawbacks of the first: damage to the collector busbars shuts off all the breakers connected to it, without losing the power of the station and without switching off any power transmission lines.

Inspection of the breaker can also be carried out very simply, without using any supplementary disconnectors other than those fitted on either side of the breaker.

The number of transformer units in the second variation is less than in the first, 13 instead of 19, which undoubtedly simplifies their operation. There is a slight increase in the number of 220-kv breakers in the second variation; for the station under consideration the figures are 12 instead of 11. A serious drawback of the second variation, however, is that when the phases of the transformer are inspected, or they are shut off in an emergency, two generators must be stopped. Moreover, in order to inspect or repair the transformers without causing a prolonged interruption in the operation of the turbogenerators, a supplementary reserve transformer phase must be fitted (power 40,000 kva).

It should also be noted that having two assemblies on the generator voltage side in each transformer group (on which there are two deltas) presents well-known constructional difficulties which are absent in the first variation.

New System of Connections

The possibility of obtaining 10/220 kv 3-phase transformers up to 60,000 kva capacity enables a new system of connections to be proposed. Instead of a 120,000-kva 10/220 kv transformer group with two generator voltage windings, two 3-phase 10/220 kv transformers of 60,000 kva each can be fitted, leaving all the other elements of the connection system intact (Figure 2). When this substitution is effected, a new and very valuable quality of the connection system appears -- any transformer can be inspected by stopping its own block generator only. All that is necessary is to disconnect this transformer on the 220-kv side from the bridge piece which links each pair of blocks.

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Naturally, while this disconnecting is being done, it is necessary to switch off for a short time the other generator of the block and open both 220-kv breakers of this circuit. To save time on this operation it is advisable to fit a 220-kv disconnector at each transformer.

Installing two 3-phase transformers instead of a group of single-phase transformers also substantially reduces loss of power in the transformers when carrying out the annual generator inspection, by enabling the transformer of the generator being inspected to be switched off during this period.

The new connection system compares favorably with both of the others, as it has none of the drawbacks of the first and all the advantages of the second. Moreover, in the new system the number of transformer units is considerably smaller than in the systems discussed earlier -- six instead of 13 and 19; the need for cumbersome arrangements at generator voltage in the transformer groups decreases; relay protection of transformers is accomplished in a somewhat simpler manner; if one transformer breaks down two generators are cut out, as in the second variation. However, after it has been ascertained which of the two transformers has broken down, the damaged transformer is cut out by a disconnector and normal operation of the second, undamaged block is restored. Thus, even in the very rare case of a damaged transformer, the interruption in the work of the second generator may be of very brief duration, Under the new system, a transformer can be isolated for inspection when the load is light, when both generators can be shut down for a short period.

It should be noted that increasing the power of the transformer groups or using paired blocks in the new system of connections decreases the number of elements installed on the 220-kv side, thus facilitating the use of a polygon system of connections. For the station under discussion, the 220-kv part of the connections can be hexagonal. (See Figure 3).

The use of the hexagon system cuts the number of breakers and the size of the 220-kv open distribution installation; the number of breakers is reduced from 12 to six, and the area of the open distribution installation from 17,300 to 11,500 sq m.

Thus, the new connection system reduces the number of transformers and sometimes the number of breakers also. It enables the expenditure on capital equipment to be reduced considerably and ultimately increases the reliability and convenience of operation of this responsible part of the power systems.

/Appended figures follow./

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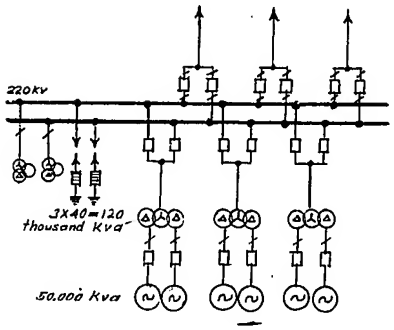

Figure 1

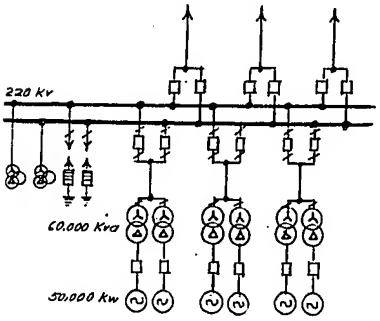

Figure 2

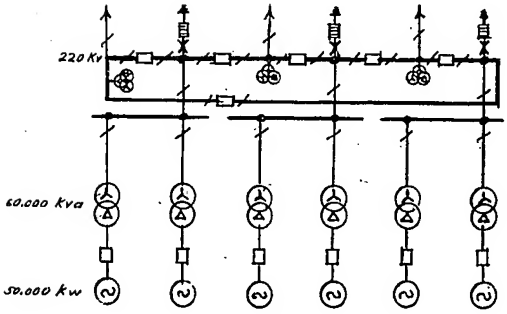

Figure 3

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